SNI

SNI 04-6507.1-2002/Amd1-2006

Standar Nasional Indonesia

Amandemen 1

Pemutus sirkit untuk proteksi arus lebih pada instalasi rumah tangga dan sejenisnya – Bagian 1: Pemutus sirkit untuk operasi arus bolak-balik

ICS : 29.120.50

Badan Standardisasi Nasional

Prakata

Standar Nasional Indonesia (SNI) mengenai "Amandemen 1 Pemutus Sirkit untuk Proteksi Arus Lebih pada Instalasi Rumah Tangga dan Sejenisnya – Bagian 1 : Pemutus sirkit untuk operasi arus bolak-balik", merupakan amandemen terhadap SNI 04-6507.1-2002 dan diadopsi secara modifikasi dari *International Electrotechnical Commission* (IEC) 60898-1 (2002) Amandemen 2 (2003-05) dengan judul "Amandement 2 *Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations - Part 1: Circuit-breakers for a.c. operation*".

SNI ini menggunakan Amandemen 2 dari standar *International Electrotechnical Commission* (IEC) 60898-1 (2003-05). karena SNI 04-6507.1-2002 sudah mencakup amandemen 1 dari standar *International Electrotechnical Commission* (IEC) 60898-1 (2002).

Dalam SNI ini terminal dengan penghantar alumunium tidak diijinkan untuk digunakan di Indonesia

SNI ini dibuat masih dalam metode republikasi *(republication)* sesuai dengan acuan dan ketentuan yang berlaku dan akan dijadikan dalam Bahasa Indonesia dalam jangka waktu tertentu sesuai ketentuan yang berlaku dari Badan Standardisasi Nasional (BSN).

SNI ini dirumuskan oleh Panitia Teknis Peranti/Pemanfaat Listrik (PTPM) melalui proses/prosedur perumusan standar dan terakhir dibahas dalam Forum Konsensus XXIV pada tanggal 6-7 Desember 2005 di Jakarta.

Dalam rangka mempertahankan mutu ketersediaan SNI yang tetap mengikuti perkembangan, maka diharapkan masyarakat standardisasi ketenagalistrikan memberikan saran dan usul untuk revisi SNI ini dikemudian hari.

NORME INTERNATIONALE

INTERNATIONAL STANDARD

CEI
IEC
60898-1

2002

AMENDEMENT 2
AMENDMENT 2
2003-05

Amendement 2

Petit appareillage électrique – Disjoncteurs pour la protection contre les surintensités pour installations domestiques et analogues –

Partie 1: Disjoncteurs pour le fonctionnement en courant alternatif

Amendment 2

Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations –

Part 1: Circuit-breakers for a.c. operation

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FOREWORD

This amendment has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

The text of this amendment is based on the following documents:

FDIS	Report on voting
23E/521/FDIS	23E/525/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2007. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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CONTENTS

Add to the annex list, on page 5, the title of the new annex L as follows:

Annex L (normative) Specific requirements for circuit-breakers with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors

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2 Normative references

Add to the existing list the titles of the following standards:

IEC 60228A:1982, First supplement to Publication 228, *Conductors of insulated cables – Guide to the dimensional limits of circular conductors*

IEC 61545, *Connecting devices – Devices for the connection of aluminium conductors in clamping units of any material and copper conductors in aluminium bodied clamping units* – Group safety publication

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Annexes

Add the new Annex L as follows:

Annex L
(normative)

Specific requirements for circuit-breakers with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors

L.1 Scope

This annex applies to circuit-breakers within the scope of this standard, equipped with screw-type terminals of copper – or of alloys containing at least 58 % of copper (if worked cold) or at least 50 % of copper (if worked otherwise), or of other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable – for use with untreated aluminium conductors, or with screw-type terminals of aluminium material for use with copper or aluminium conductors.

In this annex copper-clad and nickel-clad aluminium conductors are considered as aluminium conductors.

NOTE In Austria, Australia and Germany, the use of aluminium screw-type terminals for use with copper conductors is not allowed.

– In Austria, Switzerland and Germany, terminals for aluminium conductors only are not allowed.

– In Spain, the use of aluminium conductors is not allowed for final circuits in household and similar installations e.g. offices, shops..

– In Denmark, the minimum cross-sectional area for aluminium conductors is 16 mm^2.

L.2 Normative references

Void.

L.3 Definitions

As a complement to clause 3, the following additional definitions apply for the purpose of this annex.

L.2.1
treated conductor
contact area of a conductor that has had its oxide layer on the outside strands scraped away and/or has had a compound added to improve connectability and/or prevent corrosion

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L.2.2
untreated/unprepared conductor
conductor which has been cut and the insulation of which has been removed for insertion into a terminal

NOTE A conductor, the shape of which is arranged for introduction into a terminal or the strands of which are twisted to consolidate the end, is considered to be an unprepared conductor.

L.2.3
equalizer
arrangement used in the test loop to ensure an equipotentiality point and uniform current density in a stranded conductor, without adversely affecting the temperature of the conductor(s)

L.2.4
reference conductor
continuous length of the same type and size conductor as that used in the terminal unit under test and connected in the same series circuit. It enables the reference temperature and, if required, reference resistance to be determined

L.2.5
stability factor Sf
measure of temperature stability of a terminal unit during the current cycling test

L.4 Classification

Clause 4 applies.

L.5 Characteristics of circuit-breakers

Clause 5 applies.

L.6 Marking

In addition to clause 6 the following requirements apply:

The terminal marking defined in table L.1 shall be marked on the circuit-breaker, near the terminals.

The other information concerning the number of conductors, the screw torque values (if different from table 10) and the cross-sections, shall be indicated on the circuit-breaker.

Table L.1 – Marking for terminals

Conductor types accepted	Marking
Copper only	None
Aluminium only	Al
Aluminium and copper	Al/Cu

The manufacturer shall state in his catalogue that, for the clamping of an aluminium conductor the tightening torque shall be applied with appropriate means.

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L.7 Standard conditions for operation in service

Clause 7 applies.

L.8 Constructional requirements

Clause 8 applies, with the following exceptions:

8.1.5.2 *is completed by:*

For the connection of aluminium conductors, circuit-breakers shall be provided with screw-type terminals allowing the connection of conductors having nominal cross-sections as shown in table L.2.

Terminals for the connection of aluminium conductors and terminals of aluminium for the connection of copper or aluminium conductors shall have mechanical strength adequate to withstand the tests of 9.4, with the test conductors tightened with the torque indicated in table 10, or with the torque specified by the manufacturer, which shall never be lower than that specified in table 10.

Table L.2 – Connectable cross-sections of aluminium conductors for screw-type terminals

Rated Current [a] A	Range of nominal cross-sections [b] to be clamped mm^2
Up to and including 13	1 to 4
Above 13 up to and including 16	1 to 6
Above 16 up to and including 25	1,5 to 10
Above 25 up to and including 32	2,5 to 16
Above 32 up to and including 50	4 to 25
Above 50 up to and including 80	10 to 35
Above 80 up to and including 100	16 to 50
Above 100 up to and including 125	25 to 70

[a] It is required that, for current ratings up to and including 50 A, terminals be designed to clamp solid conductors as well as rigid stranded conductors; the use of flexible conductors is permitted. Nevertheless, it is permitted that terminals for conductors having cross-sections from 1 mm^2 up to 10 mm^2 be designed to clamp solid conductors only.

[b] Maximum wire sizes of table 5, increased according to table D.2 of IEC 61545.

Compliance is checked by inspection, by measurement and by fitting in turn one conductor of the smallest and one of the largest cross-section areas as specified.

8.1.5.4 *The text of 8.1.5.4 is replaced by:*

Terminals shall allow the conductors to be connected without special preparation.

Compliance is checked by inspection and the tests of L.9.

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L.9 Tests

Clause 9 applies, with the following modifications/additions:

For the tests which are influenced by the material of the terminal and the type of conductor that can be connected, the test conditions of table L.3 are applied.

Additionally the test of L.9.2 is carried out on terminals separated from the circuit-breaker.

Table L.3 – List of tests according to the material of conductors and terminals

Material of terminals	Material according to 8.1.4.4 [a]	Al [a]	
Material of conductor (table L.1)	Al Use tables L.2 and L.5	Cu Use tables 5 and 9	Al Use tables L.2 and L.5
9.4 Reliability of screws	Use tables L.2, L.5 and 10	Use tables 5, 9 and 10	Use tables L.2, L.5 and 10
9.5.1 Pull-out test [b]	Use tables L.2, L.5 and 10	Use tables 5, 9 and 10	Use tables L.2, L.5 and 10
9.5.2 Damage of the conductor	Use tables L.2, L.5 and 10	Use tables 5, 9 and 10	Use tables L.2, L.5 and 10
9.5.3 Insertion of the conductor	Use table L.4	Use table 12	Use table L.4
9.8 Temperature rise	Use table L.5	Use table 9	Use table L.5
9.9 28-day test	Use table L.5	Use table 9	Use table L.5
L.9.2 Cycling test	Use table 10	Use table 10	Use table 10

[a] Use test sequences A and B and number of samples defined in Annex C. For circuit-breakers which are able to be connected to Al or Cu conductors, the test sequences and number of samples have to be doubled (one for the Cu conductor and one for the Al conductor)

[b] For the pull-out test 9.5.1, the value for 70 mm^2 wire is under consideration.

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Table L.4 – Connectable conductors and their theoretical diameters

Metric					AWG				
Rigid			Flexible (copper only)		Rigid			Flexible (copper only)	
S	Solid	Stranded	S			Solid [a]	Class B stranded [a]		Classes [b] I, K, M stranded
mm^2	Ø mm	Ø mm	mm^2	Ø mm	Gauge	Ø mm	Ø mm	Gauge	mm
1,0	1,2	1,4	1,0	1,5	18	1,07	1,23	18	1,28
1,5	1,5	1,7	1,5	1,8	16	1,35	1,55	16	1,50
2,5	1,9	2,2	2,5	2,3[c]	14	1,71	1,95	14	2,08
4,0	2,4	2,7	4,0	2,9 [c]	12	2,15	2,45	12	2,70
6,0	2,9	3,3	4,0	2,9 [c)]	10	2,72	3,09		
10,0	3,7	4,2	6,0	3,9	8	3,43	3,89	10	3,36
16,0	4,6	5,3	10,0	5,1	6	4,32	4,91	8	4,32
25,0		6,6	16,0	6,3	4	5,45	6,18	6	5,73
35,0		7,9	25,0	7,8	2	6,87	7,78	4	7,25
					1	7,72	8,85		
50,0		9,1	35	9,2	0	8,51	9,64		12,08
70,0		12,0	50	12	00	9,266	10,64		

NOTE Diameters of the largest rigid and flexible conductors are based on IEC 60228A, table 1 and, for AWG conductors, on ASTM B 172-71, ICEA S-19-81, ICEA S-66-524, ICEA S-68-516.

[a] Nominal diameter + 5 %.

[b] Largest diameter + 5 % for any of the three classes I, K, M.

[c] Dimensions for class 5 flexible conductors only, according to IEC 60228A.

L.9.1 Test conditions

Subclause 9.1 applies, except that the Al conductors to be connected are taken from table L.5.

Table L.5 – Cross sections (S) of aluminium test conductors corresponding to the rated currents

S mm^2	I_n A
1,5	$I_n \leq 6$
2,5	$6 < I_n \leq 13$
4	$13 < I_n \leq 20$
6	$20 < I_n \leq 25$
10	$25 < I_n \leq 32$
16	$32 < I_n \leq 50$
25	$50 < I_n \leq 63$
35	$63 < I_n \leq 80$
50	$80 < I_n \leq 100$
70	$100 < I_n \leq 125$

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L.9.2 Current cycling test

This test verifies the stability of the screw-type terminal by comparing the temperature performance with that of the reference conductor under accelerated cycling conditions.

This test is carried out on separate terminals.

L.9.2.1 Preparation

The test is performed on four specimens, each one made by a couple of terminals, assembled in a manner which represents the use of the terminals in the circuit-breaker (see examples shown in figures L.2 to L.6). The screw-type terminals which have been removed from the product shall be attached to the conducting parts of the same cross-section, shape, metal and finish as that on which they are mounted on the product. The screw-type terminals shall be fixed to the conducting parts in the same manner (position, torque, etc.) as on the product. If one specimen fails during the test, four other specimens shall be tested and no other failures are admitted.

L.9.2.2 Test arrangement

The general arrangement of the samples shall be as shown in figure L.1.

Ninety per cent of the value of torque stated by the manufacturer or, if not stated, selected in table 10 shall be used for the test specimens.

The test is carried out with conductors according to table L.5. The length of the test conductor from the point of entry to the screw-type terminal specimens to the equalizer (see L.3.3) shall be as in table L.6.

Table L.6 – Test conductor length

Conductor cross section mm^2	Conductor wire size AWG	Minimum conductor length mm
S ≤ 10,0	≤ 8	200
16,0 ≤ S ≤ 25,0	6 to 3	300
35,0 ≤ S ≤ 70,0	2 to 00	460

Test conductors are connected in series with a reference conductor of the same cross-section.

The length of the reference conductor shall be approximately at least twice the length of the test conductor.

Each free end of the test and reference conductor(s) not connected to a screw-type terminal specimen shall be welded or brazed to a short length of an equalizer of the same material as the conductor and of cross section not greater than that given in table L.7. All strands of the conductor shall be welded or brazed to make an electrical connection with the equalizer.

Tool-applied compression type terminations without welding may be used for the equalizer if acceptable to the manufacturer and if the same performance is provided.

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Table L.7 – Equalizer and busbar dimensions

Range of test current *A*	*Maximum cross section* *mm²*	
	Al	*Cu*
0 - 50	*45*	*45*
51 – 125	*105*	*85*
126 - 225	*185*	*155*

The separation between the test and reference conductors shall be at least 150 mm.

The test specimen shall be suspended either horizontally or vertically in free air by supporting the equalizer or busbar by non-conductive supports so as not to subject the screw-type terminal to a tensile load. Thermal barriers shall be installed midway between the conductors which shall extend 25 mm ± 5 mm widthways and 150 mm ± 10 mm lengthways beyond the screw-type terminals (see figure L.1). Thermal barriers are not required provided the specimens are separated by at least 450 mm. The specimens shall be located at least 600 mm from the floor, wall or ceiling.

The test specimens shall be located in a substantially vibration-free and draught-free environment and at an ambient temperature between 20 °C and 25 °C. Once the test is started, the maximum permissible variation is ±1 K provided the range limitation is not exceeded.

L.9.2.3 Temperature measurement

Temperature measurements are made by means of thermocouples, using a wire having a cross-section of not more than 0,07 mm² (approximately 30 AWG).

For screw-type terminals, the thermocouple shall be located on the conductor entry side of the screw-type terminal, close to the contact interface.

For the reference conductor, the thermocouples shall be located midway between the ends of the conductor, and under its insulation.

Positioning of the thermocouples shall not damage the screw-type terminal or the reference conductor.

NOTE 1 Drilling of a small hole and subsequent fastening of the thermocouple is an acceptable method, provided that the performance is not affected and that it is agreed by the manufacturer.

The ambient temperature shall be measured with two thermocouples in such a manner as to achieve an average and stable reading in the vicinity of the test loop without undue external influence. The thermocouples shall be located in a horizontal plane intersecting the specimens, at a minimum distance of 600 mm from them.

NOTE 2 A satisfactory method for achieving a stable measurement is, for example, to attach the thermocouple to unplated copper plates approximately 50 mm × 50 mm, having a thickness between 6 mm and 10 mm.

L.9.2.4 Test method and acceptance criteria

NOTE 1 Evaluation of performance is based on both the limit of screw-type terminal temperature rise and the temperature variation during the test.

The test loop shall be subjected to 500 cycles of 1 h current-on and 1 h current-off, starting at an a.c. current equal to 1,12 times the test current value determined in table L.8. Near the end of each current-on period of the first 24 cycles, the current shall subsequently be adjusted to raise the temperature of the reference conductor to 75°C.

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At the 25th cycle the test current shall be adjusted for the last time and the stable temperature shall be recorded as the first measurement. There shall be no further adjustment of the test current for the remainder of the test.

Temperatures shall be recorded for at least one cycle of each working day, and after approximately 25, 50, 75, 100, 125, 175, 225, 275, 350, 425, and 500 cycles.

The temperature shall be measured during the last 5 min of the current-on time. If the size of the set of test specimens or the speed of the data acquisition system is such that not all measurements can be completed within 5 min, the current-on time shall be extended as necessary to complete such measurements.

After the first 25 cycles the current-off time may be reduced to a time 5 min longer than the time necessary to all terminal assemblies for cooling down to a temperature between ambient temperature T_a and T_a + 5 K during the current-off period. Forced-air cooling may be employed to reduce the off time, if acceptable to the manufacturer. In that case it shall be applied to the entire test loop and the resulting temperature of the forced air shall not be lower than the ambient air temperature.

The stability factor Sf for each of the 11 temperature measurements is to be determined by subtracting the average temperature deviation D from the 11 values of the temperature deviation d.

The temperature deviation d for the 11 individual temperature measurements is obtained by subtracting the associated reference conductor temperature from the screw-type terminal temperature.

NOTE 2 The value of *d* is positive if the screw-type temperature is higher than that of the reference conductor and negative if it is lower.

For each screw-type terminal

- *the temperature rise shall not exceed 110 K;*
- *the stability factor Sf shall not exceed ±10 °C.*

An example of calculation for one screw-type terminal is given in table L.9.

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Table L.8 – Test current as a function of rated current

Metric sizes		
Rated current A	Al conductor size mm²	Test current A
$0 \le I_n \le 15$	2,5	26
$15 < I_n \le 20$	4	35
$20 < I_n \le 25$	6	46
$25 < I_n \le 32$	10	60
$32 < I_n \le 50$	16	79
$50 < I_n \le 65$	25	99
$65 < I_n \le 80$	35	137
$80 < I_n \le 100$	50	171
$100 < I_n \le 125$	70	190

AWG		
Rated current A	Al conductor size N°	Test Current A
$0 < I_n \le 15$	12	30
$15 < I_n \le 25$	10	40
$25 < I_n \le 40$	8	53
$40 < I_n \le 50$	6	69
$50 < I_n \le 65$	4	99
$65 < I_n \le 75$	3	110
$75 < I_n \le 90$	2	123
$90 < I_n \le 100$	1	152
$100 < I_n \le 120$	0	190

Table L.9 – Example of calculation for determining the average temperature deviation D

Temperature measurement	Cycle Number	Temperatures		Temperature deviation *d = a - b* K	Stability factor *Sf = d - D* K
		Screw-type terminal *a* °C	Reference conductor *b* °C		
1	25	79	78	1	0,18
2	50	80	77	3	2,18
3	75	78	78	0	−0,82
4	100	76	77	−1	−1,82
5	125	77	77	0	−0,82
6	175	78	77	1	0,18
7	225	79	76	3	2,18
8	275	78	76	2	1,18
9	350	77	78	−1	−1,82
10	425	77	79	−2	−2,82
11	500	81	78	3	2,18

Average temperature deviation $D = \dfrac{\Sigma d}{\text{number of measurements}} = \dfrac{9}{11} = 0{,}82$

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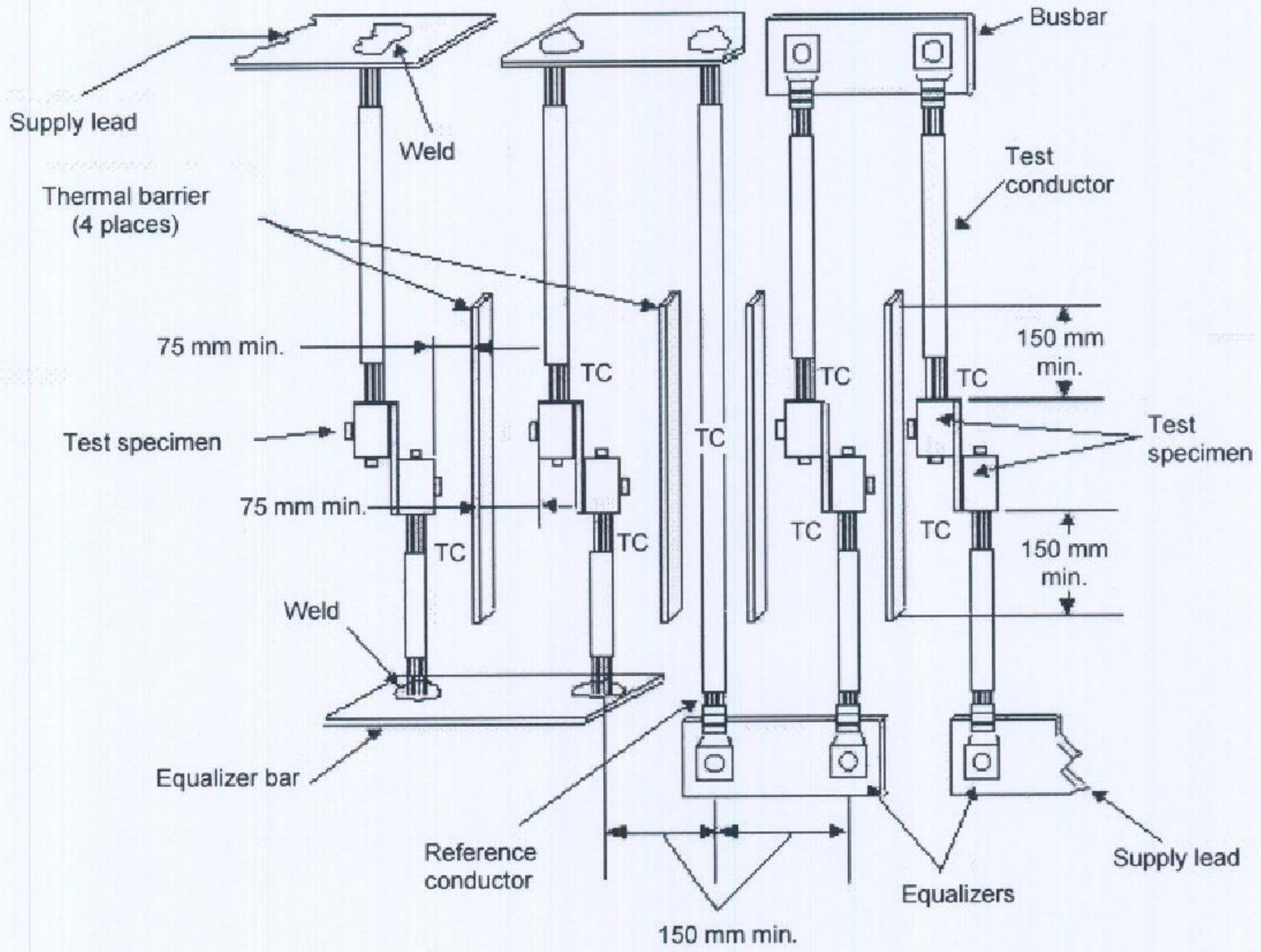

TC Thermocouple

IEC 1542/03

Figure L.1 – General arrangement for the test

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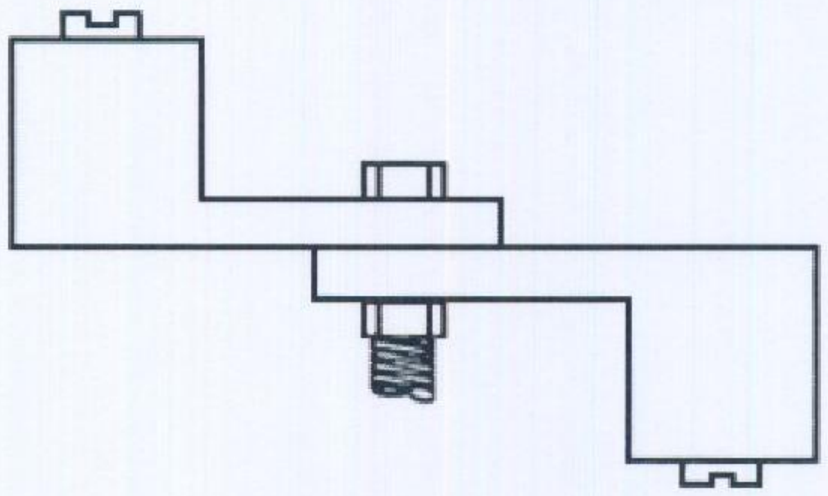

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NOTE The conducting part may be bolted, soldered or welded.

Figure L.2

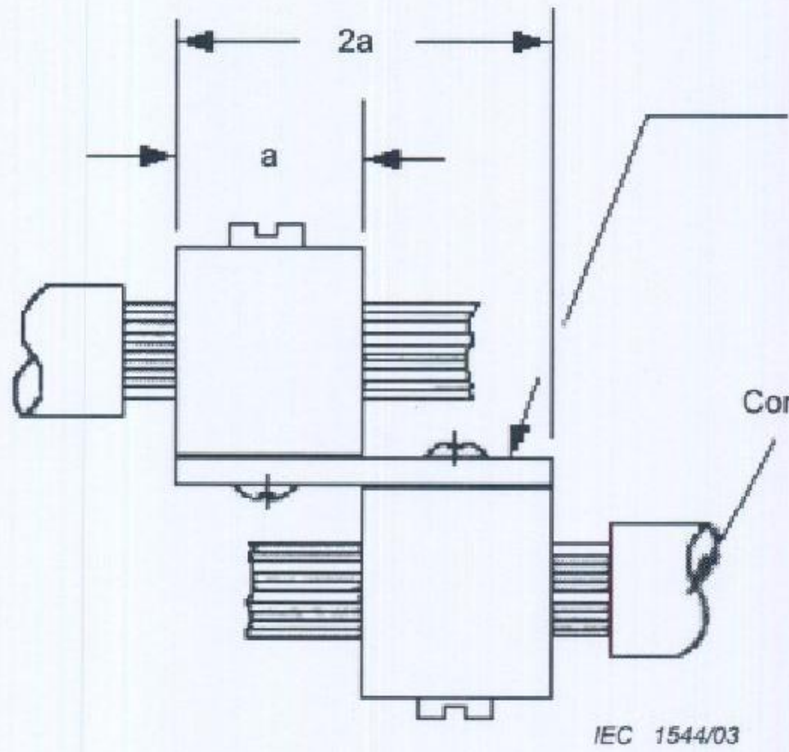

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Figure L.3

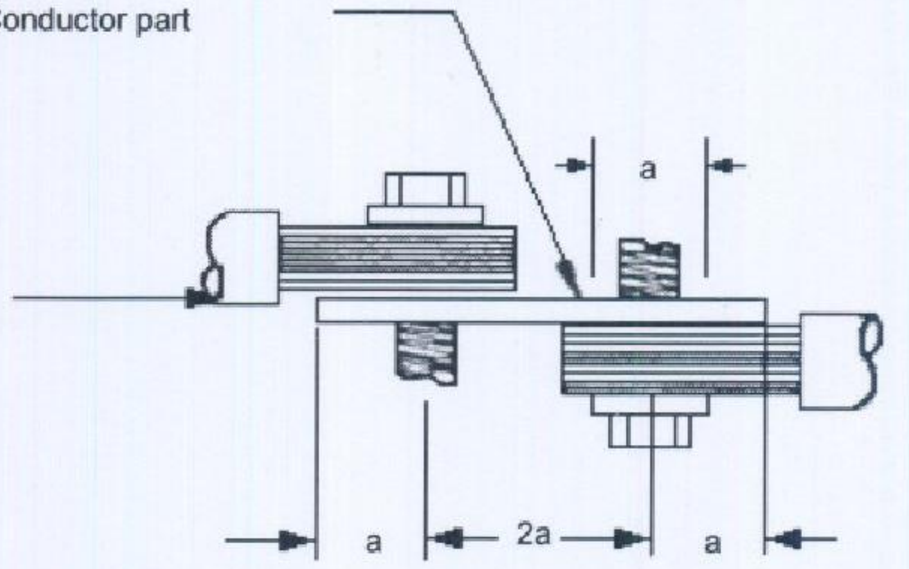

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Figure L.4

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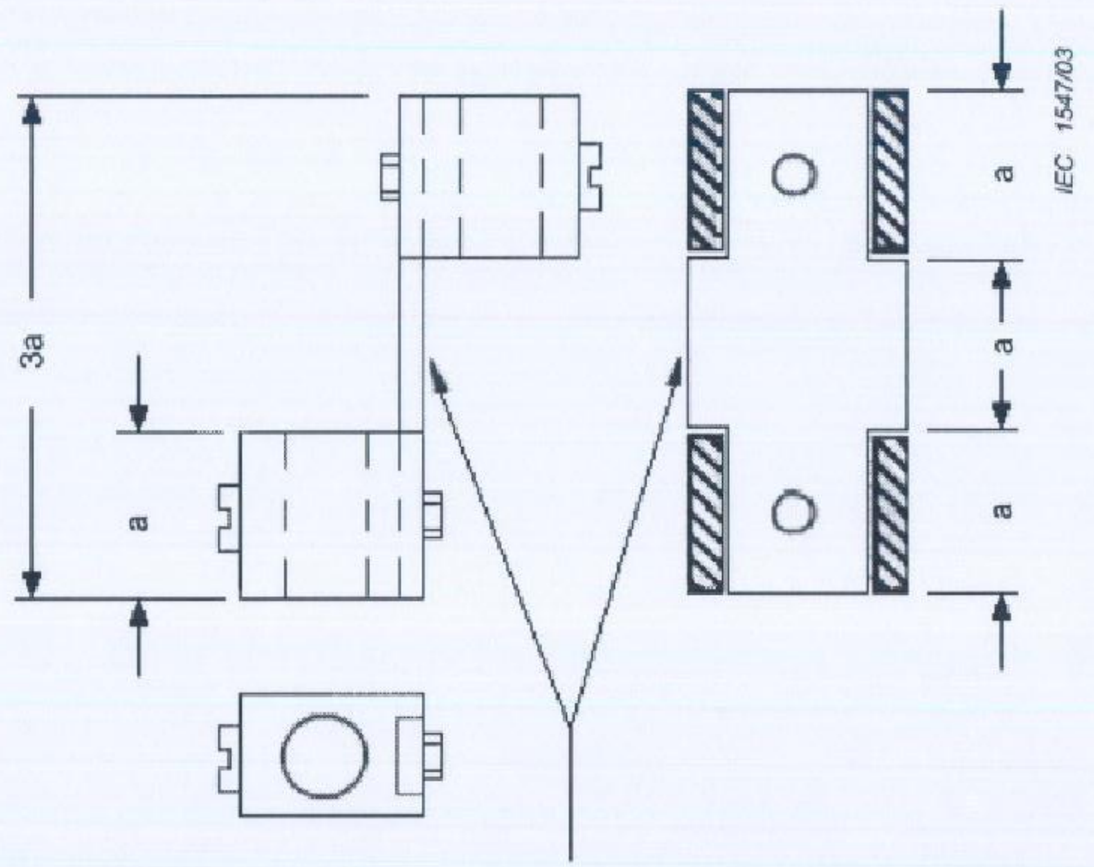

Figure L.6

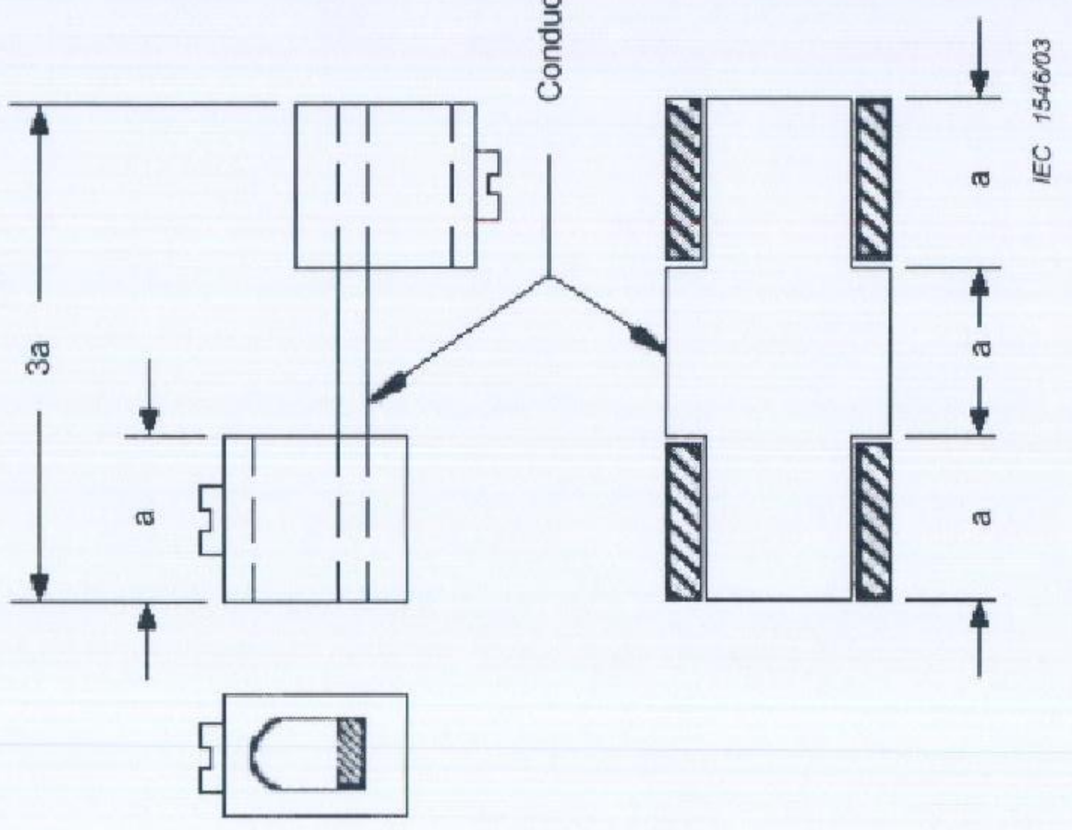

Figure L.5

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